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(71)(72) Applicants and Inventors: STEFANOW, Alexander, R. [BG/BG]; 17, "H. Dimitar" Str., B, 1000 Sofia (BG). STEFANOW, Ivan, R. [BG/BG]; 17, "H. Dimitar" Str., B, 1000 Sofia (BG). PETKOV, Ranguel, N. [BG/BG]; 20, "Arch. Milanov" Str., 1126 Sofia (BG).

(74) Agent: VARBANOV, Julian, I.; Patent and Trademark Bureau, 3, Pozitano Str., Fl.2, 1000 Sofia (BG).

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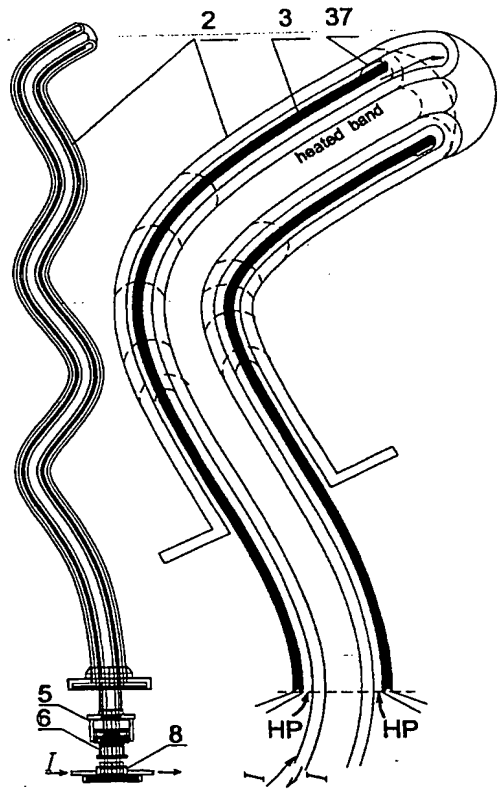
(54) Title: CANNULA WITH A BUILT–IN NET FOR MANAGEMENT, HYDRAULIC DIRECTION AND A CONTROL SYSTEM

(57) Abstract

The cannula with a built–in net for management, hydraulic direction and a control system for penetration via three–coordinate trajectory to a point, which is unapproachable in a straight line, with a minimum impact on the environment, is applied in microsurgery, diagnostics, anatomy research, as well as to observe and influence the conditions of objects within limited closed spaces. It consists three tubes, placed coaxial into one another, of which the inner–most central tube is a working cannula for visualisation and operative intervention, the second tube above it with a controllable transition from solid into high elastic state, its front end is fixed to a flange and the tube is turned inside out over a third leading tube, the front end of which directs the turning, and the back end is connected with the body of a hydraulic cylinder through the piston of which on the axis there pass the first and the second tube. The second tube is sealed with an elastic ring with the piston, so that the pressure of the piston on the lubrication liquid in the cylinder to carry it in the form of lubrication layer between the second and the third tubes until the front end of the cannula, where the controllable tube turns inside out. By means of management of pressure and elastification through longitudinal bands in the wall of the controllable tube there is achieved a direction of the process of its turning on the set direction.



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CANNULA WITH A BUILT-IN NET FOR MANAGEMENT, HYDRAULIC DIRECTION AND A CONTROL SYSTEM

FIELD OF THE INVENTION

The subject of the invention is a cannula with a built-in net for management, hydraulic direction and a control system applied for access via three-coordinate trajectory to a point, which is unapproachable in a straight line, with a minimum impact on the environment, applied in microsurgery, diagnostics, anatomy research, as well as to observe and influence the conditions of objects within limited close spaces.

BACKGROUND OF THE INVENTION

Decisions are known of units for penetration, tests and microsurgery in the human body via the blood vessels, the digestive and the secretory systems. They consist of a flexible hose, inserted manually through a special opening and carried mainly by the walls of the selected vessel and directed by means of a fibre-endoscope through rotation of a flexible metal cord or through direction by means of a magnet device, placed in the front end of the hose and an outside magnet field, or by means of a micromotor with an electrical direction control [1-12].

The penetration in this manner does not allow to obtain an access in exactly set trajectory and to obtain a stable basis for the devices to operate with. In the course of penetration and removal of the device a friction in the surrounding tissues is felt along its whole length.

Another decision of the cannula [13] is also known, consisting of a cylinder membrane, turned inside out, like the snail horn, where between the inner and the outer wall a passive flexible hose is placed concentrically, closed by the membrane as well as a lubrication liquid. After turning out the outer wall solidifies and directs the movement of the inner flexible wall and the forward movement is effected by pushing the inner wall of the membrane by means of the leading tube of a fibre-endoscope device.

This decision removes the friction at the time of penetration and taking out the cannula to a great extent and establishes a stable basis for the operation devices

on account of the solid outer wall, but thus the device does not allow any connection to a real control system and can not function in practice.

SUMMARY OF THE INVENTION

The task of the invention is to create a device, preserving the advantage of the cannula turning inside out by itself, connecting it with a hydraulic system for energy transport, building a elastification control net and effecting a connection to the computerised control system.

The cannula with a built-in control net, hydraulic direction and control system consists of three tubes, inserted coaxially into one another. The inner central tube is a working cannula for visualisation and operational intervention, the second tube has controllable transition from a solid into a plastic state, initially being fixed to a flange and turned inside out, in order to cover the inlet of the third leading tube, the front end of which directs the turning, and the back end is connected with the body of the hydraulic cylinder through the piston, where the first and the second tubes pass along the axis. The second tube and the piston are sealed with a plastic ring in such a manner, that the pressure of the piston on the lubrication liquid of the cylinder to carry it in form of a lubrication layer between the second and the third tubes, until the front end of the cannula, where the turning out of the controllable tube is effected.

The first tube is flexible, with a metal cover. Its back end is connected with a flange.

The controllable tube is made of polymer, with a programmable temperature transition from solid into high elastic state, and inside its wall there is a built-in electricity conduction net for control of the state, connected with a flange - collector, which is fixed to the back end of this tube. According to the technology of placing the control net inside the polymer, three types of tubes with controllable elastification are created:

- wound and pressed foil of the polymer, upon which, after a preliminary metalisation and photo-lithographic processing a metal net is obtained, divided as cross segments on the one part, and longitudinal bands, on the other part. Having been wound, the cross segments form a spiral wound ring with a contact lead off the inner part and connected with a common rim on the other part, which is electrically

connected with a flange - collector, and the longitudinal bands are placed along the inner side of the tube, isolated from each other, and connected with a corresponding segment of the flange - collector.

- extruded tube of polymer with longitudinal bands, placed inside the wall, isolated from each other and knit from metal fibres, and from each knot of the stitch a lead on the outer side of the tube is left for an el. contact. Each band is connected with a corresponding segment of the flange - collector.

- knit tube of hollow textile fibres, filled in advance with metal low-temperature substance with exactly determined transition from crystal into liquid phase and vice - versa. The tube is impregnated with an elastic polymer. The longitudinal fibres in the back end are grouped and connected with a corresponding segment of the flange - collector.

The third tube, the leading one, is flexible, but tensile and stretch resistant. There is a metal ring in the front end.

A second alternative for execution of the third tube has been developed as well, aiming at high-quality control. The tube consists of an elastic non-polar polymer with built-in metal fibres, isolated from each other and led out to the back end of the tube. There they are divided into four groups of lines and each is connected with a cable to the corresponding lead of a 4-channel high-frequency generator, with its common pole connected with the collector, which is bound with the back end of the first tube. In this way of high-frequency management, the controllable tube is simply extruded from a polymer with dipole molecules and a low-temperature transition from solid into high elastic state.

The cannula is placed in a manipulation device, consisting of a body, where linear guides are fixed, where 4 carriages are sliding, each of them with separate programmable drive. The flange at the front of the cannula is fixed in a slot at the front end of the manipulator. The cylinder is fixed to the first carriage, the piston - to the second one, the flange-collector - to the third one, and the flange of the first tube - to the fourth one. Each carriage is connected with optical sensors to an item, according to the body of the manipulator and the element, carried by it. The volume of the cylinder of the cannula is linked via flexible hose to a pressure sensor and to the hydraulic pump.

The electrical leads of the flanges of the first and the second tube are connected via flexible symmetric cable to the outlet of a programmable generator of high - frequency impulses and the outlet of the segments of the flange - collector. - with conductors - to the programmable el. power sources. The generator and the sources are linked through the data processing unit to the managing computer. The programmable settings of the carriages into motion, the hydraulic pump and the corresponding sensors to them are also connected via control device for step - coordinate management to the managing computer.

The cannula with a built-in network for management and hydraulic direction and a control system makes a programmable access possible via three- coordinate trajectory to a point, which is inaccessible through a straight line within a limited closed space with many fixed objects inside. The constructing the cannula, its outer wall remains relatively immobile in relation to the environment, as a result of the fact, that the movement process of the materials for the cannula, the power for the movement and the signals for the movement are limited by the stable outer wall. At the time of penetration and removal of the device there is no friction between its outer wall and the surrounding objects. A stable basis is achieved for the operating instruments on account of the solid outer wall. By means of the hydraulic system, connected to the cannula, the power for the forward movement is transferred by the pressure of the liquid and at the same time a lubrication is effected between the walls of the coaxial placed tubes. By means of a built-in network for management with el. impulses of the transition from solid into high elastic state and vice versa the cannula is accessible for connection and management by computer with a software.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 shows a cannula assembly with a built-in network for management with a hydraulic cylinder, mounted thereto, and the connection items to the driving and control systems.

Figure 2 shows a lay out of the devices for movement of the cannula elements.

Figure 3 shows an example for execution of the controllable tube, made of polymeric foil with the topology of the wire net and the assembling sequence.

Figure 4 shows another execution of the controllable tube by means of extrusion, where longitudinal bands are placed inside the wall, which are isolated from each other and knit by metal fibres.

Figure 5 shows the third alternative of execution of the controllable tube by means of knitting of hollow fibres, filled in advance with metal low-temperature substance with exactly determined transition from crystal into liquid phase and vice versa.

Figure 6 shows 2 ways of execution of the third leading tube and the connection of the built-in lines in case of high - frequency management of the elastification.

Figure 7 shows the manner of movement and direction of the cannula with management of pressure and elastification of the controllable tube.

Figure 8 shows the lay-out of the connection within the cannula management system.

EXAMPLES

The cannula with a built-in network for management, hydraulic direction and control system as shown in figure 1 consists of 3 tubes, placed into one another coaxially. The innermost - the central tube 1 is a working cannula for visualisation and operative intervention. The controllable tube 2 is with controllable transition from solid to plastic state, at the beginning being fixed to the front flange 4 and then turns inside out in such a manner as to cover the beginning of the third leading tube 3, the front end of which directs the turning out and the back end is connected with the body 5 of the hydraulic cylinder by means of piston 6, where the first and the second tube pass symmetrically around the axis, where the latter is sealed with the elastic ring 7 to the piston in such a manner, as the pressure of the piston to transfer the lubrication layer between the second 2 and the third 3 tubes until the front of the cannula, where the turning out of the controllable tube is effected.

The first tube is flexible with a metal outside cover. Its back end is connected electrically and mechanically with the back flange 10.

The controllable tube 2 is made of polymer with a programmable transition from solid into high elastic state. An electricity conduction net for control of the state is built in its wall. It is connected with the flange - collector 9 - 8q fixed in the

back end of the tube. Figures 3, 4 and 5 demonstrate three alternatives for execution of this tube, according to the technology and management of the plastification.

Tube 2, shown on figure 3, consists of polymeric foil upon which, after preliminary metalisation and photolithographic processing a metal net is developed, divided into cross-segments 23 on the one part, and longitudinal bands 24 on the other part, and after winding and forming the cross-segments form spiral wound rings with a contact lead out from the inner side and connected by a common rim 25 on the other side, which is connected electrically with flange 9, and the longitudinal bands 24 are placed along the outer part of the tube 2, isolated from each other and linked to the corresponding segments of collector 8.

The second alternative for assembly of tube 2, as shown in fig. 4, consists of tube 26 extruded by polymer with controllable elasticity with longitudinal bands 27, 28, 29, 30 placed inside the wall, which are isolated from each other and knit by metal fibres, from each knot of the pleat a lead to the outer wall of the tube is left for el. contact, and each of the bands 27, 28, 29, 30 is connected with a corresponding segment of the collector 8.

The third alternative for assembly of tube 2, as shown in fig. 5, consists of a tube knit by hollow textile fibres 313, filled in advance with low-temperature substance 32 and bands from longitudinal fibres 33 - 36, knit inside the fibres electrically insulated from each other, and the tube is impregnated with an elastic polymer, but in such a manner that from the outer side of the wall to have open points for el. contact with each stitch of the metal fibres, and each of the bands 33, 34, 35 and 36 is connected with a corresponding segment of the collector 8.

The leading tube 3 is flexible, but tensile and stretch resistant. In the front end there is a metal ring 37, forming the forehead and along the inside walls there is a narrow peripheral strip, as shown in fig. 6a.

There is also a second alternative for the leading tube 3q shown on fig. 6 b, for a high - frequency management. The tube consists of an elastic non-polar polymer with built-in longitudinal metal fibres 38, insulated from each other and a lead to the back end of the tube 3, where they are divided in four groups of lines 39, 40, 41 and 42, in which each of them is connected with a cable to a corresponding lead of the four-channel high-frequency generator 48, and its common pole is connected with the collector 10 of the central tube 1. In this way of high - frequency

management the controlled tube is simply extruded by a polymer with dipole molecules and a low-temperature transition from a solid into high elastic state.

The cannula is placed in a manipulator, shown in fig. 2 for co-ordinated mechanical direction, consisting of a body 11, where linear guides 12 are fixed, where the carriages 13, 14, 15 and 16 are gliding, each of them equipped with a separate programmable device. The front flange 4 of the cannula is fixed inside a slot of the front end of the body 11 of the manipulator. The cylinder 5 is fixed to the first carriage 13, the piston 6 - to the second - 14, the flange - collector 8-9 - to the third 15 and the back flange 10 - to the fourth one. Each carriage is connected by means of optical sensors with an item according to the body of the manipulation device and the element, carried by it. The volume of the cylinder 5 of the cannula is connected by means of flexible hose with a control unit for the hydraulic pressure 21.

The el. leads from flanges 9 and 10 are connected with a flexible symmetrical cable to the outlet of a programmable generator of el. impulses PSP 47, and the leads of the longitudinal bands 27, 28, 29 and 30 from the flange - collector 8 - 9 are connected with a band cable through circuit - breaker K1-K4, 43 to the outlet of generator of el. impulses PSD 46, as shown in fig. 8. Through the control unit for elastification and reading of the pressure these generators are included in a computer system for program control 50.

The system also includes step motors M1, M2, M3, M4 and M5 from drives 17, 18, 19 and 20 of the carriages 13, 14, 15, 16 and the hydraulic pump HPC 21 respectively via step control unit D1 - D5, 44.

Application and operation

The operation of the cannula at the created unit is based on complex utilisation of the opportunities for manageable transport of mechanical power through hydraulic pressure along a flexible hose, electrically impulse and high-frequence transformation of conditions of polymeric or metal composition materials in determined cross segments or longitudinal bands from the wall of the tube through a built-in net connected with el. impulse generators managed by a program.

As shown on fig. 1 and 2 with elastified inside wall of the controllable tube 2 after setting the piston 6 into motion by the carriage 14 and the motor 18 the

pressure of the liquid inside the cylinder 5 gives rise to a flow of thin coaxial layer between the second 2 and the third 3 tubes, and the pressure is transferred to the front end, where the turning is effected. Under the action of this pressure and the pushing out of the first 1 and the second 2 tubes by the piston 6, the front of the cannula moves one step forward. After that, through the carriage 13, set into motion by the motor 17, moves the cylinder 5 forward and the third 3 tube connected thereto, and the hydraulic pressure control unit 21 by means of liquid overflow obtains a pressure, equal to the air-pressure. From that moment on carriage 16 moves backward and draws half-a step back the central tube 1 in order to align its front end with the front of the cannula. This is the procedure of one cycle of operations for execution of one step forward.

The direction of the movement of the cannula and therefrom of the direction is effected by means of elastification of longitudinal bands according to the required direction along he wall of the controllable tube 2, as shown in fig. 7. Under the action of the hydraulic pressure the elastified section alongside moves overtakingly and directs the penetration by this bending of the tube.

The management of the elastification of tube 2 is effected through impulse like increase in the temperature in 2 ways - with direct current impulses or with high-frequency impulses.

The direct current impulses obtained with voltage, set by a program and duration from the generator 46 by means of the circuit - breaker 43, K1-K4, as shown in fig. 8, are fed by the collector 8 to the determined couple of longitudinal bands 27, 28, 29 and 30 or 24 RdA-D and through the creeping contact with metal ring 37 are closed in the current circuit, obtained in this way. On account of the separated energy of the impulse on the resistance of the conductors, from which the bands are obtained the temperature of the polymer rises in the corresponding part of the wall of tube 2.

During the high-frequency rise of the temperature from the programmable generator 48 a high-frequency recharge of the corresponding line 39, 40, 41 or 42 for a given direction is effected, located in the leading tube 3, in relation to the metalled tube 1, as shown in fig. 6 b, where a high-frequency alternative field is obtained in the corresponding section of the wall of the controllable tube 2, made of polymer with dipole molecules.

PATENT CLAIMS

1. The cannula with a built-in network for management, hydraulic direction and control system, consisting of three tubes, placed coaxially into one another, of which the inner-most central tube is a working cannula for visualisation and operative intervention, the second tube above it with a controllable transition from solid into plastic state and turned inside out over a third leading tube, is characterised by the features, that the central tube (1) has an outer metalled flexible wall and is mechanically and electrically connected with its back end to a flange (10), the second controllable tube (2), fixed with its front end to the front flange (4) has a built-in conductive net, connected with its back end electrically with a collector (8) and a flange - collector (9), and the leading tube (3) for hydraulic direction is connected with the body of a hydraulic cylinder (5) through the piston (6) where coaxially pass the first (1) and the second (2) tubes, the latter being sealed with an elastic ring (7) with the piston (6) in such a way, that the lubrication liquid from the cylinder to forms a coaxial layer between the walls of the second (2) and the third (3) tubes, and thus the obtained cannula is based by means of a front flange (4) on the body of manipulator (11), and the cylinder (5), the piston (6), the flange - collector (9) and the flange (10) are fixed to their corresponding carriages (13), (14), (15) and (16), sliding on linear guides (12), each of them with independent drive (17), (18), (19) and (20) connected through a unit for step-like management (44) of the motors and a control unit for the elastification (45) with a computer control system (50).

2. Cannula according to claim 1, comprising a tube with a controllable transition from solid into high elastic state (2) with a built-in el. conductive net (23), (25) or (27, 28, 29,30) connected with a collector (8) and flange (9) at the back end.

3. Cannula according to claim 2, wherein the controllable tube (2) consists of a wound and sealed polymeric foil (22) where a metal layer from both sides is made in advance and by means of photolithography a wire net is obtained, divided into cross-segments (23) of the one part and longitudinal bands (24) of the other, so that after the winding the cross segments form spiral would rings with contact lead out from inside and connected with a common rim (25) on the other part, connected

electrically with the flange (9) of the flange - collector, and the longitudinal bands are placed along the inner part of the tube, isolated from each other and connected to the corresponding segment of the collector (8) to the flange - collector.

4. Cannula according to claim 2, wherein the controllable tube (2) is made of extruded polymer (26) with longitudinal bands (27), (28), (29), (30) inserted in the wall, isolated from each other and knit by wire fibres, and from each knot of the pleat a lead to the outer wall of the tube is left for el. contact, and each band is connected to corresponding segment of the flange - collector (8).

5. Cannula according to claim 2, wherein the controllable tube (2) has a wall made of parallel in length hollow textile fibres (31), filled in advance with metal low-temperature substance (32) with exactly determined transition from crystal into liquid phase and vice versa, around which metal fibres are wound spirally, grouped in four longitudinal bands (33),(34),(35),(36) from longitudinal metal fibres electrically insulated from each other, the tubes being impregnated with elastic polymer, so that from the outer part of the wall to have open points for electrical contact with each stitch of the metal fibres, and each of the bands (33),(34),(35),(36) being connected with corresponding segment of the collector (8).

6. Cannula according to claim 1, wherein the leading tube (3) is made of flexible polymer, tensile and stretch resistant, having a metal ring (37) in its front end, forming the forehead and a narrow strip in the periphery of the outer wall.

7. Cannula according to claim 1, wherein the leading tube (3) for high-frequency management of the elastification is made of elastic non-polar polymer with built-in longitudinal metal fibres (38), insulated from each other and lead to the back end of the tube (3), where they are divided into four groups of lines (39),(40),(41),(42) each of them connected with a cable to a corresponding lead of a four-channel high-frequency generator (48), and the common pole is connected with the collector (10) of the central tube (1). For this manner of high-frequency management the controllable tube (2) is simply extruded from polymer with dipole molecules and low-temperature transition from solid into plastic state.

8. Cannula according to claim 1, wherein the device for three-coordinate hydraulic direction consist of a cylinder (5) connected with a coaxial cylinder, formed between the inner wall of he third tube (3) and the controllable tube (2) in which with the piston (6) a lubrication liquid is closed, and inside the wall of the

controllable tube (2) there are longitudinal bands (27), (28), (29), (30) of conductive net with led out contact point, so that each band to be connected electrically with the ring (37) of tube (3) at the front end of the cannula and at the back end - with a segment of the flange - collector (8), connected with current impulse generator (46) managed with software.

9. Cannula according to claim 1, wherein the linear step drive consists of a body (11) with fixed therein guides (12), where on gliding bearing four carriages are placed (13), (14), (15), (16) with independent drive (17), (18), (19), (20), each with corresponding socket, where there are placed - for the first one (13) - the cylinder (5), for the second (14) - the piston (6), for the third (15) - the flange - collector (8-9) and for the fourth - the flange (10), where in the front end of the body (11) the front flange (4) is fixed in a slot.

10. Cannula according to claim 1, wherein the management of the cannula consists of computer (50) and connected with in by means of information rim motion control (44) for management of step motors connected for the drives (17), (18), (19), (20) and the hydraulic pump (21) and elastification / direction controller (45), connected with the current impulse generators (46), (47), with a high-frequency generator (48) and sensors for positioning, pressure and temperature.

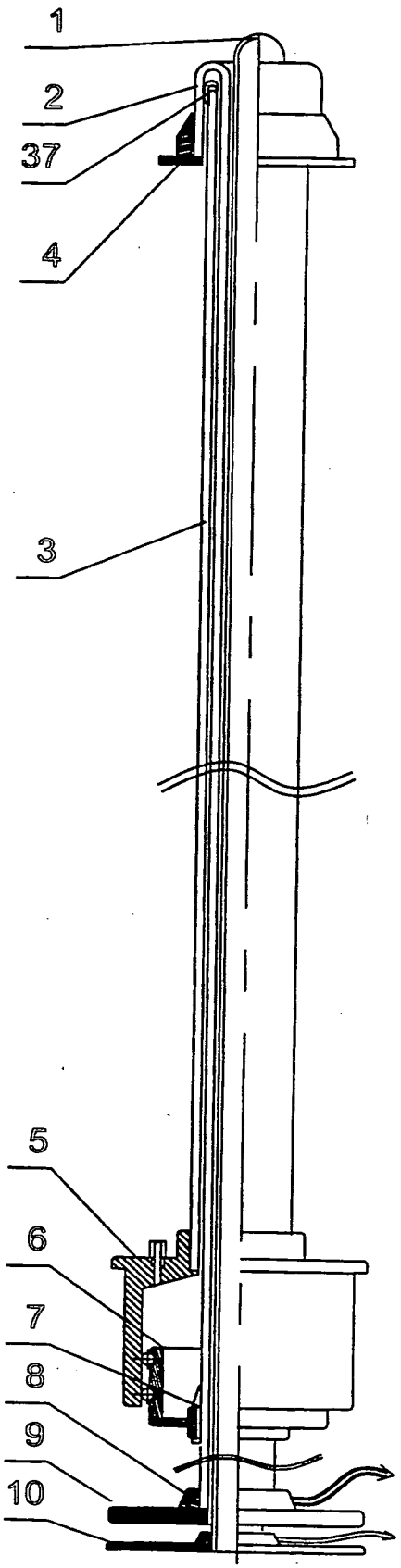


Fig.1

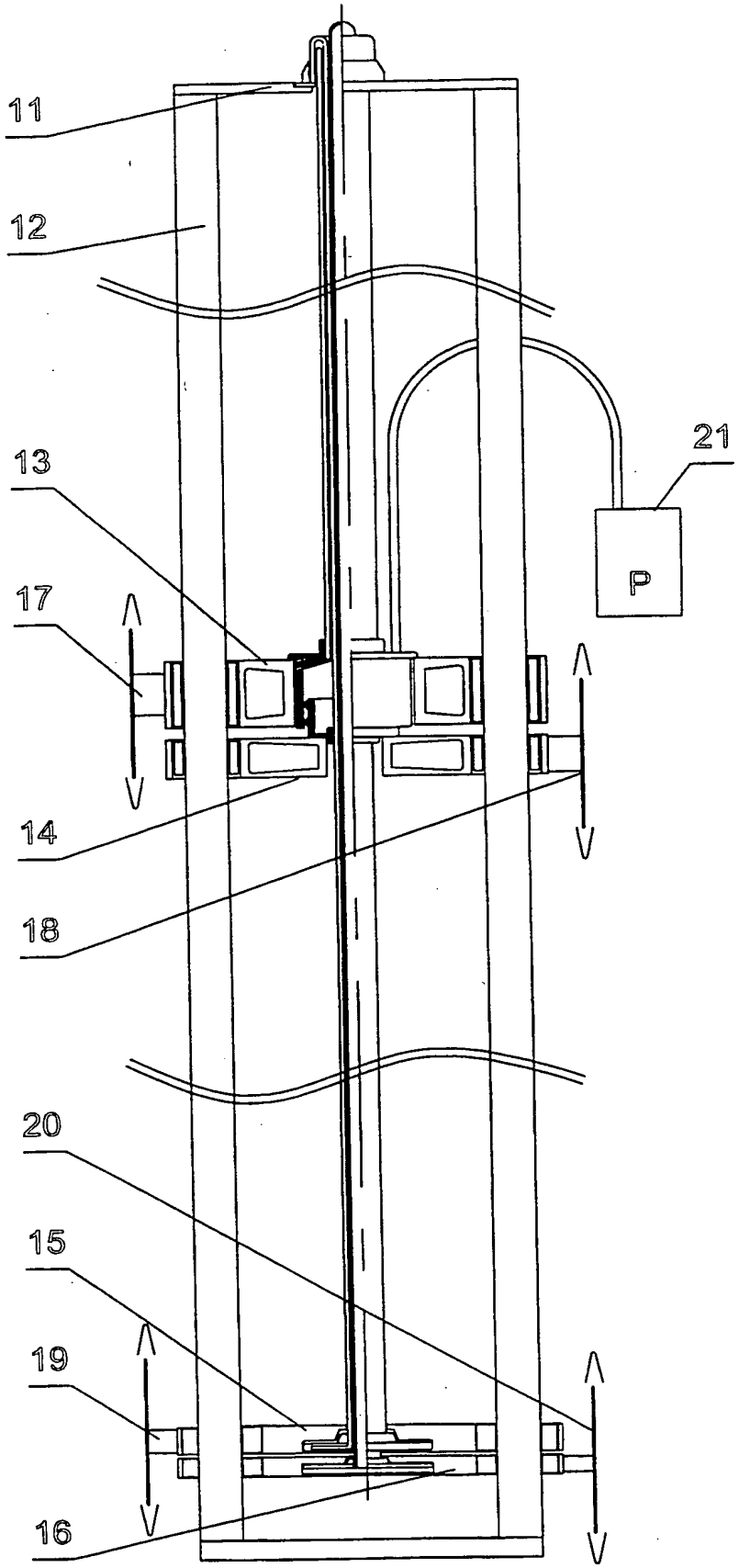


Fig.2

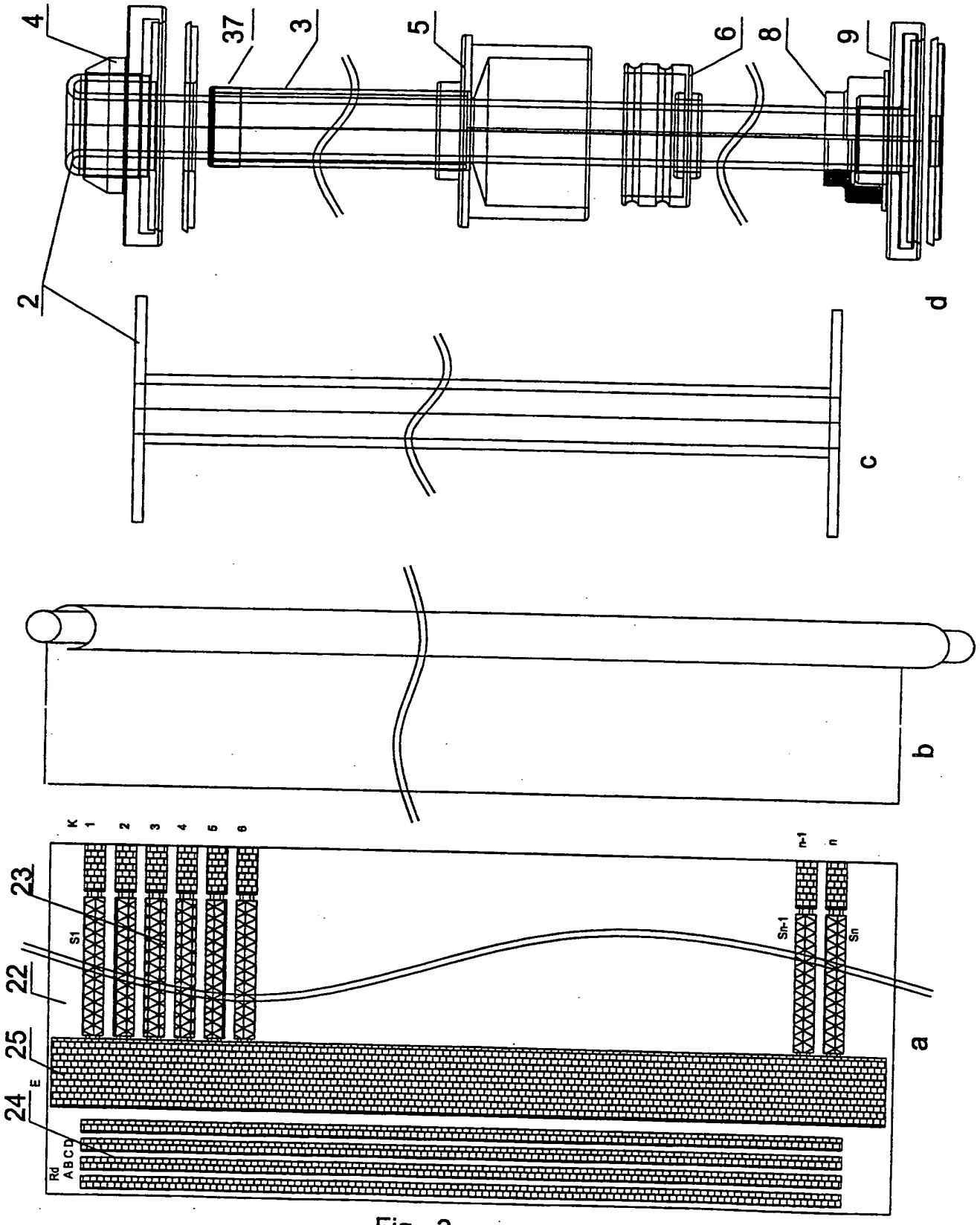
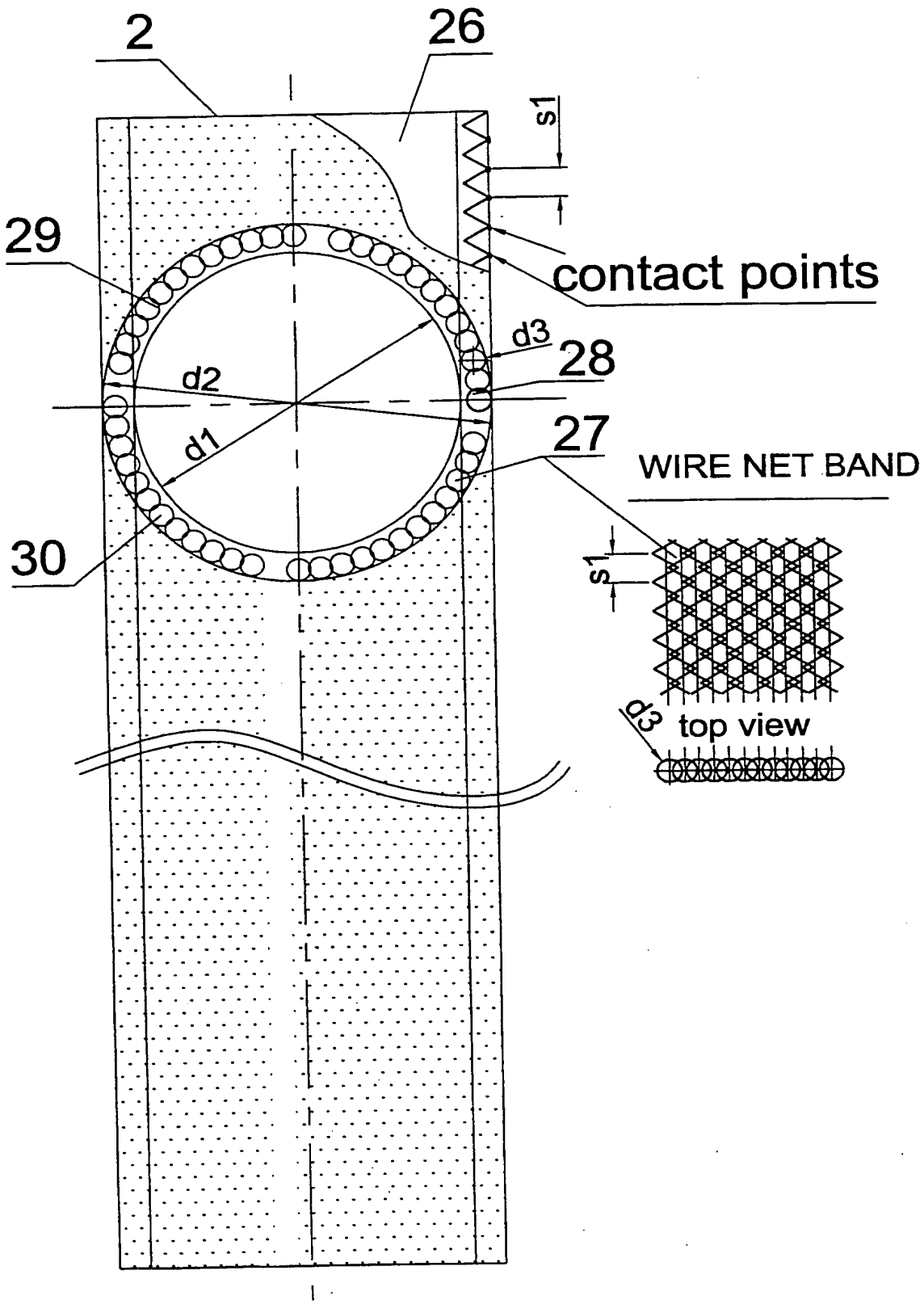


Fig. 3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26
s1
29
contact points
d3
28
d2
d1
27
WIRE NET BAND
30
s1
d3
top view

Fig. 4

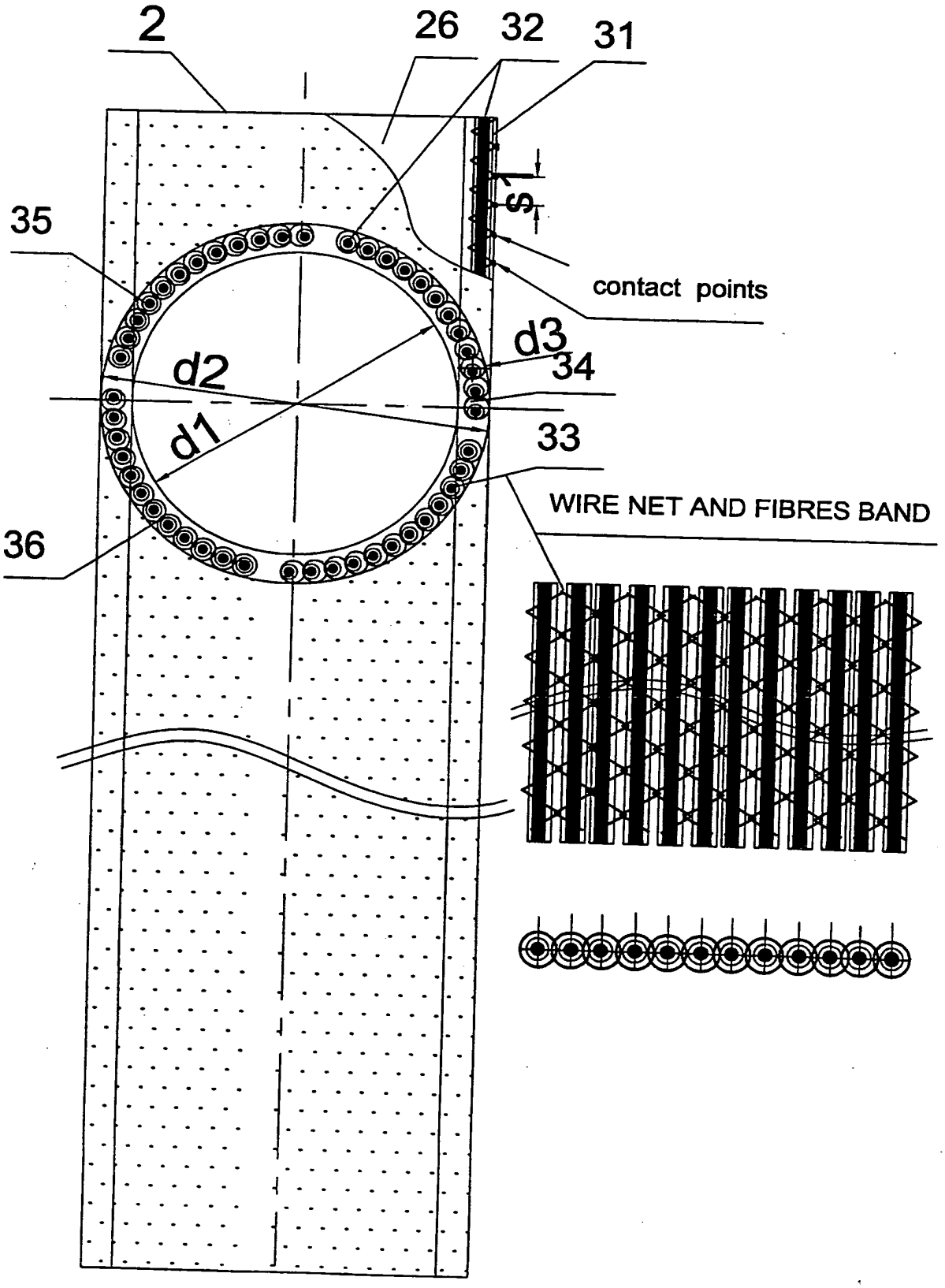

Fig. 5

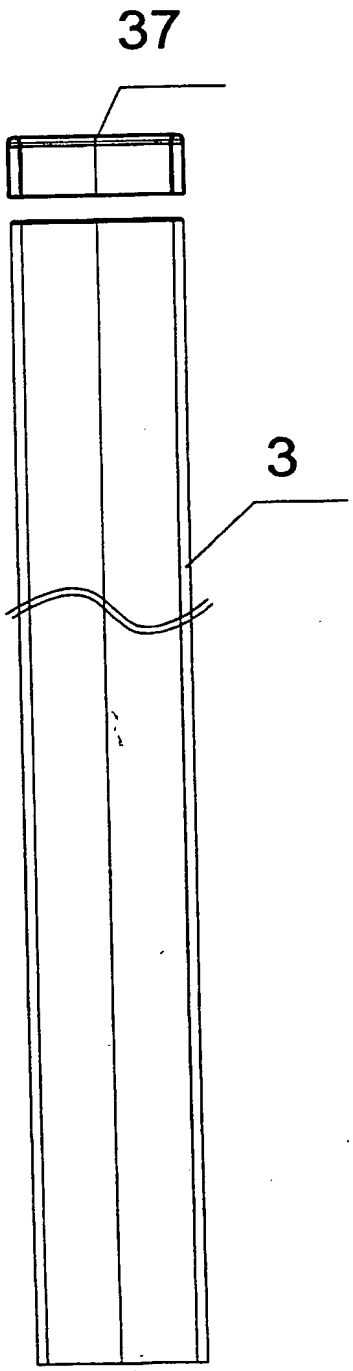

Fig. 6a

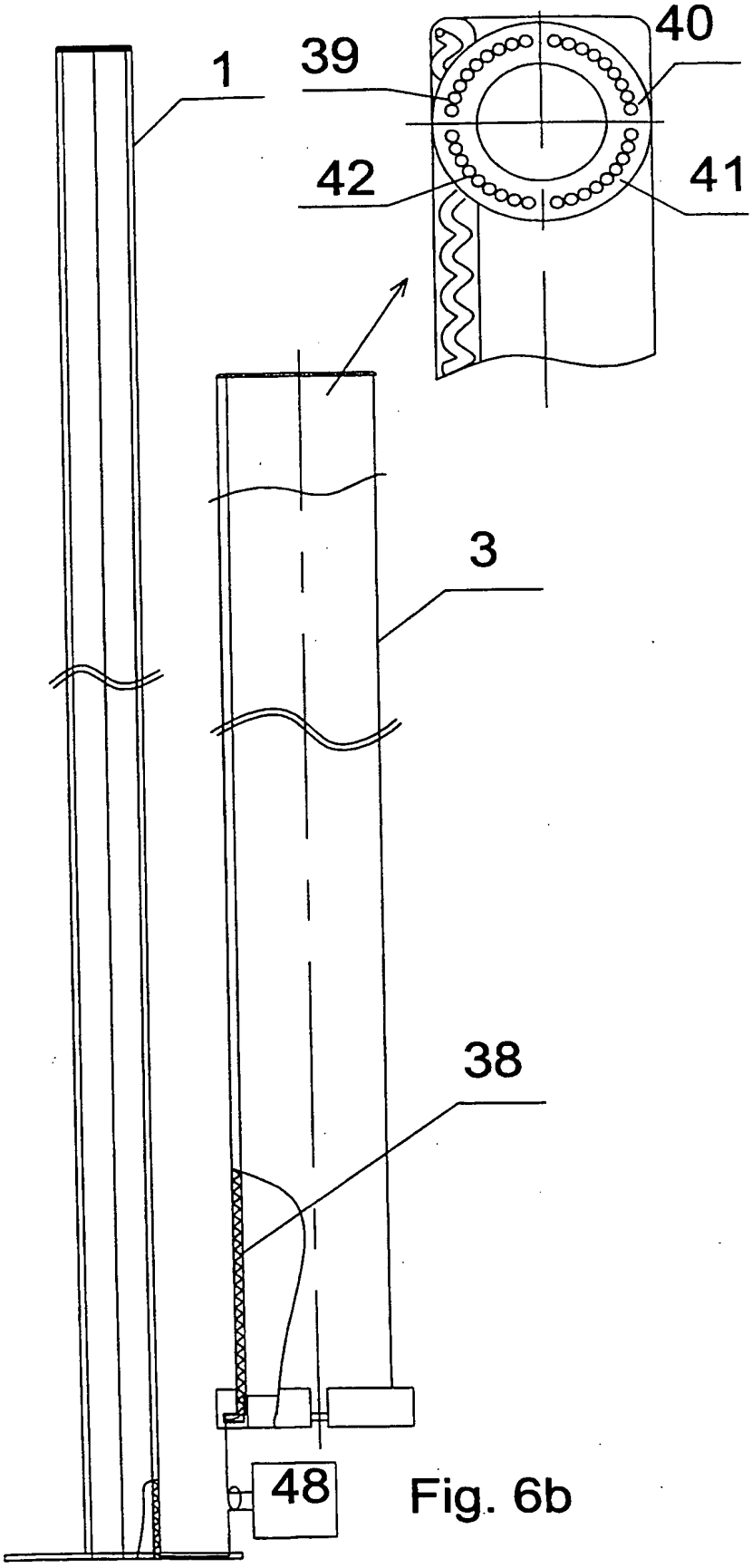

Fig. 6b

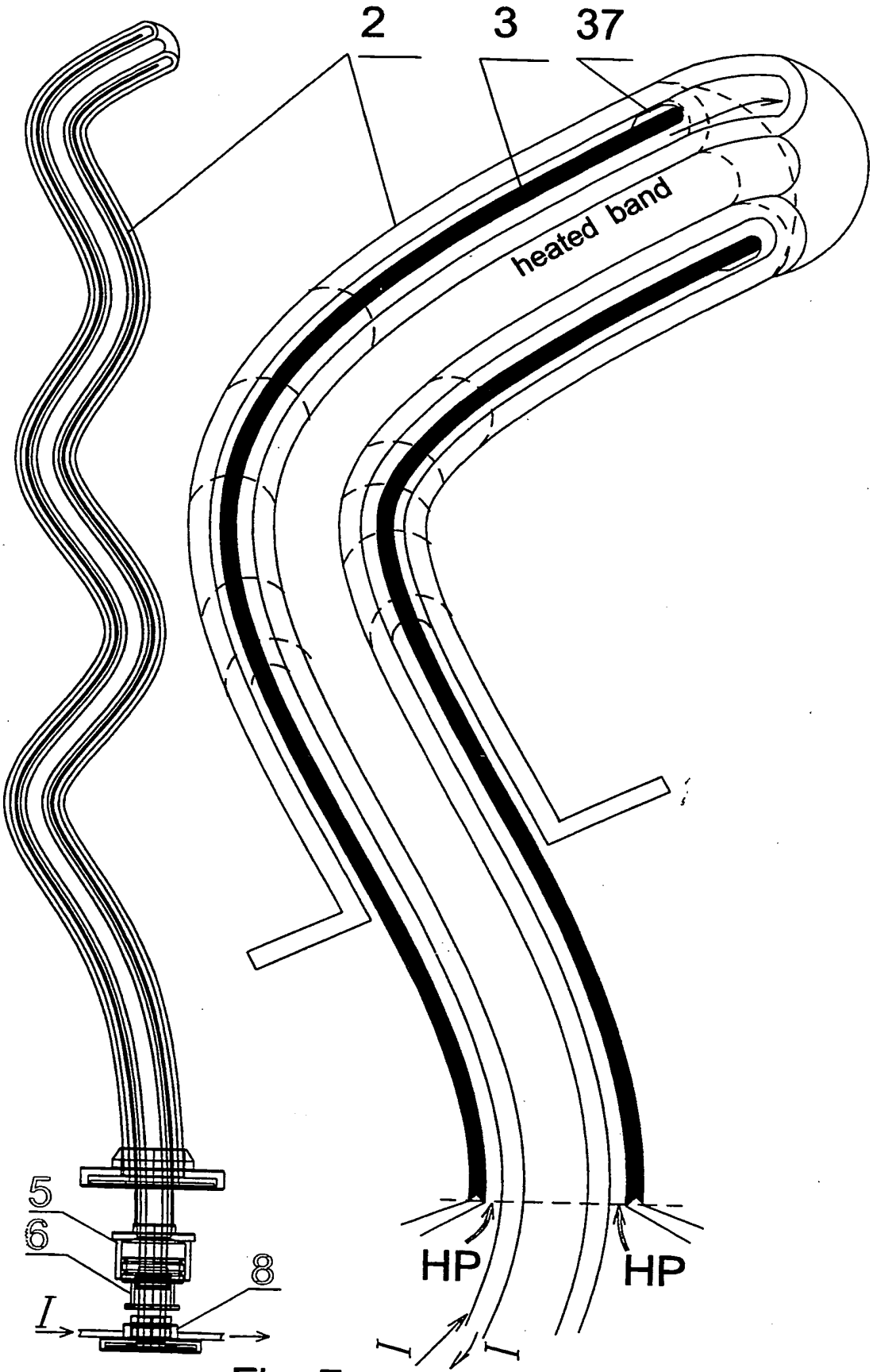

Fig. 7

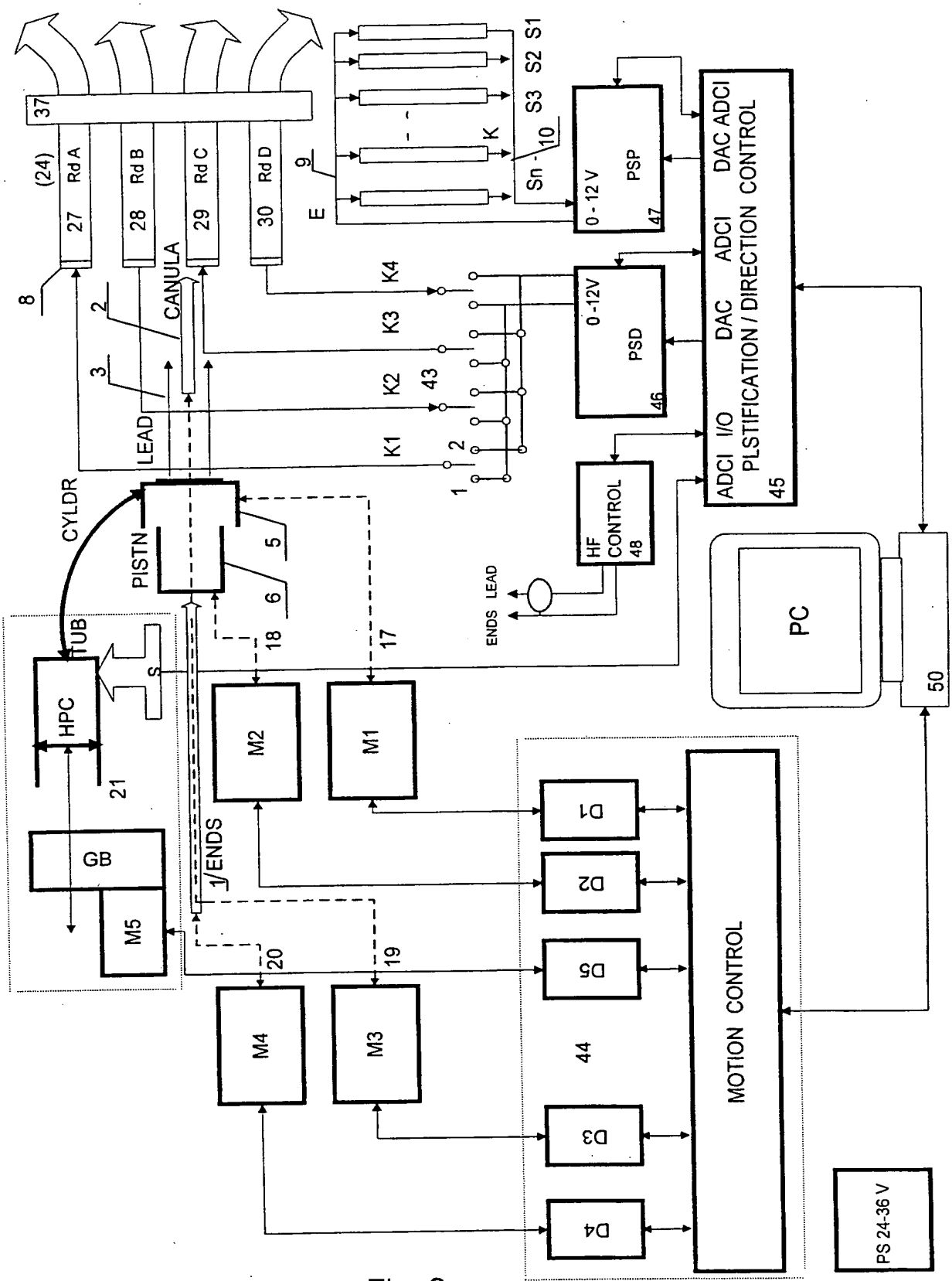

Fig. 8

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(71)(72) Applicants and Inventors: STEFANOW, Alexander, R. [BG/BG]; 17, "H. Dimitar" Str., B, 1000 Sofia (BG). STEFANOW, Ivan, R. [BG/BG]; 17, "H. Dimitar" Str., B, 1000 Sofia (BG). PETKOV, Ranguel, N. [BG/BG]; 20, "Arch. Milanov" Str., 1126 Sofia (BG).

(74) Agent: VARBANOV, Julian, I.; Patent and Trademark Bureau, 3, Pozitano Str., Fl.2, 1000 Sofia (BG).

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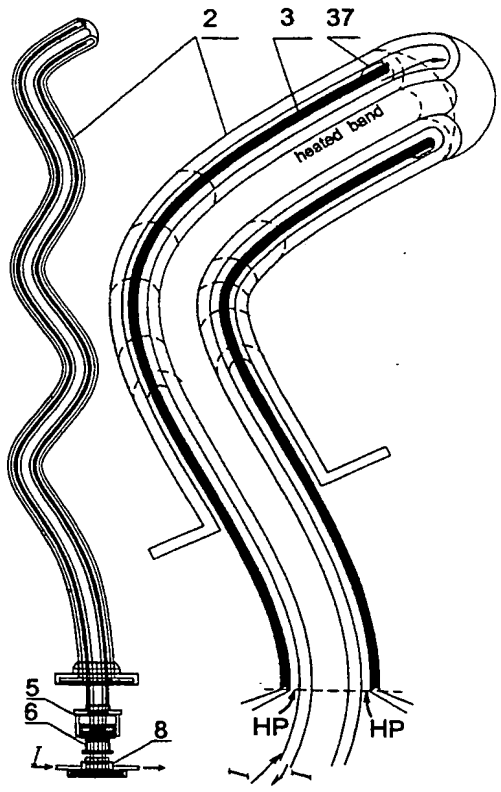
(57) **Abstract**

The cannula with a built–in net for management, hydraulic direction and a control system for penetration via three–coordinate trajectory to a point, which is unapproachable in a straight line, with a minimum impact on the environment, is applied in microsurgery, diagnostics, anatomy research, as well as to observe and influence the conditions of objects within limited closed spaces. It consists three tubes, placed coaxial into one another, of which the inner–most central tube is a working cannula for visualisation and operative intervention, the second tube above it with a controllable transition from solid into high elastic state, its front end is fixed to a flange and the tube is turned inside out over a third leading tube, the front end of which directs the turning, and the back end is connected with the body of a hydraulic cylinder through the piston of which on the axis there pass the first and the second tube. The second tube is sealed with an elastic ring with the piston, so that the pressure of the piston on the lubrication liquid in the cylinder to carry it in the form of lubrication layer between the second and the third tubes until the front end of the cannula, where the controllable tube turns inside out. By means of management of pressure and elastification through longitudinal bands in the wall of the controllable tube there is achieved a direction of the process of its turning on the set direction.



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Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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